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Test Procedure for Hum Modulation

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1. Introduction

1.1. Executive Summary

This test procedure provides instructions for how to measure hum modulation in active and passive broadband RF telecommunications equipment (taps, line passives, RF Amplifiers, Optical Nodes, etc.) in a laboratory environment. This procedure is not intended for field measurements.

1.2. Scope

The purpose of this test procedure is to define and measure hum modulation in active and passive broadband RF telecommunications equipment and sub-assemblies. This procedure presents two methods for measuring hum modulation in the time domain, with a sensitivity exceeding -80 dB. These methods are referred to as the 1 dB delta and the differential voltage method. A mathematical relationship between time domain and frequency domain measurement methods is also provided.

This document provides specifications or procedures for frequencies up to 1002 MHz. DOCSIS 3.1 specifications include operation at frequencies up to 1218 MHz, and optionally, to 1794 MHz. Specifications or procedures for those higher frequencies should be considered in a future revision of this document.

1.3. Benefits

In a coaxial telecommunications system, AC power and radio frequency (RF) signals can exist on the same conductor. As a result, amplitude modulation of the transmitted signals at the power line frequency (hum modulation) can occur in both active and passive equipment due to excessive ac voltage at the output of a local power pack (in the case of an active device) or from parametric modulation of magnetic components (used in circuitry to separate power and signal voltages) in active or passive devices.

In North American NTSC analog television systems, the frame repetition rate is 59.94 Hz and the commercial power frequency is 60 Hz. Amplitude modulation of the transmitted signals at the power line frequency (hum modulation) can cause picture disruption in the form of horizontal bars or brightness variation. Excessive hum modulation could also disrupt AGC circuitry commonly used in RF amplifiers, causing excessive RF level variations in the HFC plant.

The FCC (Title 47, Part 76.605) requires that hum modulation does not exceed 3% of the visual signal level.

This test procedure for hum modulation, when executed according the procedure, will yield confidence in the measured hum modulation performance of the active or passive broadband RF telecommunications equipment under test. Use of this test procedure provides a means for the user to verify acceptable performance of the unit under test.

1.4. Intended Audience

The intended audience for this test procedure includes manufacturers, corporate engineers, technical operations, and technicians.

1.5. Areas for Further Investigation or to be Added in Future Versions

None at the time of update.

Specifications or procedures for frequencies above 1002 MHz should be considered in a future revision of this document.

2. Normative References

The following documents contain provisions, which, through reference in this text, constitute provisions of this document. At the time of Subcommittee approval, the editions indicated were valid. All documents are subject to revision; and while parties to any agreement based on this document are encouraged to investigate the possibility of applying the most recent editions of the documents listed below, they are reminded that newer editions of those documents might not be compatible with the referenced version.

2.1. SCTE References

- ANSI/SCTE 96, 2013, Cable Telecommunications Testing Guidelines

2.2. Standards from Other Organizations

- No normative references are applicable.

2.3. Published Materials

- No normative references are applicable.

3. Informative References

The following documents might provide valuable information to the reader but are not required when complying with this document.

3.1. SCTE References

- ANSI/SCTE 82, 2012, Test Method for Low Frequency and Spurious Disturbances

3.2. Standards from Other Organizations

- 47eCFR76, Electronic Code of Federal Regulations (e-CFR), Title 47, Telecommunication, Part 76, Subpart K, 76.605 – Multichannel Video and Cable Television Service

3.3. Published Materials

- Ciciora, Farmer, Large, Adams. (2004) *Modern Cable Television Technology (2nd Edition)*. San Francisco: Morgan Kaufmann. P461-463, 631

4. Compliance Notation

<i>shall</i>	This word or the adjective “ required ” means that the item is an absolute requirement of this document.
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5. Abbreviations and Definitions

5.1. Abbreviations

AC	alternating current
AM	amplitude modulation
dB	decibel
DC	direct current
DUT	device under test
FCC	Federal Communications Commission
GHz	gigahertz
HFC	hybrid fiber-coax
Hz	hertz
kHz	kilohertz
ms	millisecond
mv	millivolt
RF	radio frequency
SCTE	Society of Cable Telecommunications Engineers
VSWR	voltage standing wave ratio

5.2. Definitions

Hum Modulation	The amplitude distortion of a signal caused by the modulation of the signal with components of the power source. It is the ratio, expressed in dB, of the peak to peak variation of the carrier level caused by AC power line frequency products (and harmonics up to 1 kHz) to the peak voltage amplitude of the carrier.
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Peak Voltage Amplitude	The maximum voltage amplitude of the carrier.
Percent Hum Modulation	Hum Modulation may also be expressed as a percentage of the peak to peak variation of the carrier level to the peak voltage amplitude of the carrier. See Appendix 3 for a derivation of percent Hum.

6. Background

In a coaxial telecommunications system, where AC power and radio frequency (RF) signals exist on the same conductor, hum modulation of a television signal is measured as a comparison between the modulation envelope (created by line power distortions of the RF carriers), and the peak voltage of the sync tips of the video signal.

In a laboratory test environment, the video signal is replaced with a sine wave RF carrier. Under these conditions, the only modulation existing on the carrier is the line power related distortion (created by the device under test) of that carrier. Hum modulation is determined as a function of the line frequency current passing through the device by comparing the peak to peak modulation envelope of the power line distortion to the peak voltage of the carrier by utilizing a diode detector.

Due to the non-linear characteristics of any diode detector, it is inaccurate to simply compare the AC modulation voltage and the rectified DC carrier voltage directly due to the voltage drop across the diode. Instead, the modulation voltage is compared to a calibrated change in the rectified carrier.

There are two time-domain methods for measuring hum modulation in a laboratory environment, which are detailed in this procedure. These methods are commonly referred to as the 1 dB delta method, and the differential voltage method. These methods are described in Appendix 5.

7. Equipment

- 7.1. The general equipment required for this test is shown in Figure 1. ANSI/SCTE 96 (Cable Telecommunications Testing Guidelines), describes and specifies this equipment.
- 7.2. The signal generator for this test must have (minimum) the characteristics listed below.
 - 7.2.1. 5 MHz – 1.002 GHz (minimum) single carrier signal generation capability.
 - 7.2.2. 0.2% minimum AM modulation index capability.
 - 7.2.3. < 0.01% residual hum.
- 7.3. Two AC/RF Power Combiners/Inserters:
 - 7.3.1. Hum modulation < -80 dB at desired test current and voltage.
 - 7.3.2. Return loss: > 22 dB.
 - 7.3.3. Power Combiners/Inserters must possess RF only input/output capability, i.e. AC blocking incorporated into design.
 - 7.3.4. Current carrying capacity of at least 50% greater than desired test currents.

Note: AC/RF Power Combiners/Inserters may not be required for certain DUT applications. Refer to Appendix 7 for special test considerations.

- 7.4. Resistive Load Bank: capable of dissipating desired test power.
- 7.5. Display Devices:
 - 7.5.1. Power analyzer capable of measuring rms current and voltage simultaneously.
 - 7.5.2. Oscilloscope must have a minimum deflection sensitivity of 2.0 mV/div.
 - 7.5.2.1. The oscilloscope used for the test must possess signal averaging capability.
- 7.6. Power supply:
 - 7.6.1. Ferro-resonant quasi-square wave (trapezoidal wave with < 100 V/ms slew rate).
 - 7.6.2. AC voltage output (50/60 Hz) at desired test voltage.
 - 7.6.3. Rated current output of at least 30% greater than the desired test current.
- 7.7. Low Pass Filter: DC – 1 kHz(minimum)
 - 7.7.1. Shielded.
 - 7.7.2. High Impedance (5 k Ω or greater).
 - 7.7.3. > 30 dB attenuation above 30 kHz.
 - 7.7.4. This filter may be contained in the differential preamplifier used in the test.
- 7.8. AM Detector:
 - 7.8.1. 75 Ω Input Impedance.
 - 7.8.2. Frequency Range: 200 kHz to 1.002 GHz.
 - 7.8.3. Maximum VSWR: 1.2:1 to 1.002 GHz.
- 7.9. Required inter-connect cables and connectors.
 - 7.9.1. Quad-shield 75 Ω coaxial cable, for RF only paths.
 - 7.9.2. Rigid or semi-rigid 75 Ω coaxial cable (1/2" diameter or greater), for RF and AC common paths, with a current carrying capacity of at least 50% greater than desired test currents.
- 7.10. Isolation Transformer
 - 7.10.1. 15 – 120 VAC Input : 115 – 120 VAC Output.
 - 7.10.2. 50/60 Hz.
 - 7.10.3. > 1,000 VA.
- 7.11. RF Amplifier